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JC784 U.S. PTO

**UTILITY PATENT APPLICATION TRANSMITTAL
(Large Entity)**

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.
POU9-1999-0176-US1

Total Pages in this Submission

TO THE ASSISTANT COMMISSIONER FOR PATENTS

Box Patent Application

Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

MEASURING UTILIZATION OF INDIVIDUAL COMPONENTS OF CHANNELS

and invented by:

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09/539024
03/30/00If a **CONTINUATION APPLICATION**, check appropriate box and supply the requisite information:☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No.: _____

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Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below
2. ☒ Specification having 49 pages and including the following:
 - a. ☒ Descriptive Title of the Invention
 - b. ☐ Cross References to Related Applications (if applicable)
 - c. ☐ Statement Regarding Federally-sponsored Research/Development (if applicable)
 - d. ☐ Reference to Microfiche Appendix (if applicable)
 - e. ☒ Background of the Invention
 - f. ☒ Brief Summary of the Invention
 - g. ☒ Brief Description of the Drawings (if drawings filed)
 - h. ☒ Detailed Description
 - i. ☒ Claim(s) as Classified Below
 - j. ☒ Abstract of the Disclosure

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Application Elements (Continued)

3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*
- a. ☐ Formal Number of Sheets _____
- b. ☒ Informal Number of Sheets 11
4. ☒ Oath or Declaration
- a. ☐ Newly executed *(original or copy)* ☒ Unexecuted
- b. ☐ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*
- c. ☒ With Power of Attorney ☐ Without Power of Attorney
- d. ☐ DELETION OF INVENTOR(S)
Signed statement attached deleting inventor(s) named in the prior application,
see 37 C.F.R. 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference *(usable if Box 4b is checked)*
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied
under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby
incorporated by reference therein.
6. ☐ Computer Program in Microfiche *(Appendix)*
7. ☐ Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all must be included)*
- a. ☐ Paper Copy
- b. ☐ Computer Readable Copy *(identical to computer copy)*
- c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☐ Assignment Papers *(cover sheet & document(s))*
9. ☐ 37 CFR 3.73(B) Statement *(when there is an assignee)*
10. ☐ English Translation Document *(if applicable)*
11. ☒ Information Disclosure Statement/PTO-1449 ☒ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☒ Acknowledgment postcard
14. ☒ Certificate of Mailing
- ☐ First Class ☒ Express Mail *(Specify Label No.):* EL497287129US

UTILITY PATENT APPLICATION TRANSMITTAL
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Total Pages in this Submission

Accompanying Application Parts (Continued)

15. ☐ Certified Copy of Priority Document(s) (if foreign priority is claimed)

16. ☐ Additional Enclosures (please identify below):

Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	54	- 20 =	34	x \$18.00	\$612.00
Indep. Claims	12	- 3 =	9	x \$78.00	\$702.00
Multiple Dependent Claims (check if applicable) <input type="checkbox"/>					\$0.00
BASIC FEE					\$690.00
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TOTAL FILING FEE					\$2,004.00

- ☐ A check in the amount of _____ to cover the filing fee is enclosed.
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Dated: March 30, 2000

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In Re Application of: Glassen et al.

Title: MEASURING UTILIZATION OF INDIVIDUAL COMPONENTS OF CHANNELS

Attorney Docket No.: POU9-1999-0176-US1 (Our Ref. No. 0560.287)

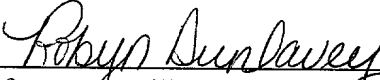
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- * U.S. Patent Application which includes:
 - Specification (29 pages), 54 Claims (19 pages), Abstract (1 page), and Eleven (11) sheets of Informal Drawings
- * Utility Patent Application Transmittal Letter (3 pages) (in duplicate)
- * Declaration and Power of Attorney for Patent Application (4 pages) (Unsigned)
- * Information Disclosure Citation (1 page) and two (2) references
- * Two (2) Acknowledgment Postcards

MEASURING UTILIZATION OF INDIVIDUAL COMPONENTS OF CHANNELS

Technical Field

5 This invention relates, in general, to channel
subsystems and, in particular, to measuring utilization of
individual components of channels of a channel subsystem.

Background Art

10 Historically, the determination of channel utilization
has been important for capacity planning, problem analysis,
as well as for performance monitoring. Previously, the
utilization of a channel path has been measured by
accumulating the amount of time that a channel is busy
during predefined time intervals. These measurements
indicate how busy a channel was during each interval, and
15 based on the measurements, work management and planning
decisions were made.

20 With the advent of more complex channels (e.g., FICON
(Fibre Connections) channels offered by International
Business Machines Corporation), the previous techniques for
measuring channel utilization are inadequate. This is
because the new channels are considered a collection of
resources and an indication of the channel being busy does
not indicate in what capacity it is busy. Thus, a need
exists for an improved measurement of channel utilization.
25 In particular, a need exists for a capability that indicates
what portion of the channel is busy and the particular
utilization of that channel portion.

Summary of the Invention

5 The shortcomings of the prior art are overcome and additional advantages are provided through the provision of a method of determining utilization of channel components of a computing environment. The method includes, for instance, obtaining measurement data for a selected component of a channel, in which the channel includes a plurality of components; and using the measurement data to determine
10 utilization of the selected component.

In one example, the method further includes obtaining one or more operational characteristics of the selected component, and in yet a further example, the one or more operational characteristics are used in determining the
15 utilization of the selected component.

In a further aspect of the present invention, a method of obtaining information associated with channel components of a computing environment is provided. The method includes, for instance, selecting a channel within the
20 computing environment to be monitored, the channel including a plurality of components; and obtaining data on one or more components of the plurality of components.

In one example, the obtaining data includes obtaining one or more operational characteristics of the one or more
25 components. In a further example, the obtaining data includes obtaining measurement data usable in determining utilization of the one or more components.

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5 In yet a further aspect of the present invention, a
6 method of determining utilization of channels of a computing
7 environment, in which the computing environment includes a
8 plurality of logical partitions, is provided. The method
9 includes, for instance, obtaining measurement data for a
10 channel, and using the measurement data to determine
11 utilization of the channel. The measurement data is
12 representative of use of the channel by the logical
13 partition involved in determining the utilization and of use
14 by one or more other logical partitions of the plurality of
15 logical partitions.

16
17 System and computer program products corresponding to
18 the above-summarized methods are also described and claimed
19 herein.

20
21 Additional features and advantages are realized through
22 the techniques of the present invention. Other embodiments
23 and aspects of the invention are described in detail herein
24 and are considered a part of the claimed invention.

Brief Description of the Drawings

25
26 The subject matter which is regarded as the invention
27 is particularly pointed out and distinctly claimed in the
28 claims at the conclusion of the specification. The
29 foregoing and other objects, features, and advantages of the
30 invention are apparent from the following detailed
31 description taken in conjunction with the accompanying
32 drawings in which:

FIG. 1 depicts one example of a computing environment incorporating and using the capabilities of the present invention;

5 FIG. 2a depicts one example of a channel utilization block used in accordance with an aspect of the present invention;

10 FIG. 2b depicts one example of a channel utilization entry of the channel utilization block of FIG. 2a, in accordance with an aspect of the present invention;

FIG. 3 depicts one example of a channel subsystem extended CPMF data area used in accordance with an aspect of the present invention;

15 FIG. 4 depicts one embodiment of various components of a channel of FIG. 1, in accordance with an aspect of the present invention;

FIG. 5 depicts one example of a channel processor universal CPMF data area used in accordance with an aspect of the present invention;

20 FIG. 6 depicts one embodiment of the logic used to set the appropriate mode for a channel processing measurement facility used in accordance with an aspect of the present invention;

25 FIG. 7 depicts one embodiment of the logic associated with an overview of how to determine

utilization of various components of a channel, in accordance with an aspect of the present invention;

FIG. 8 depicts one embodiment of the logic associated with an operating system determining the utilization of one or more channel components, in accordance with an aspect of the present invention;

FIG. 9a depicts one embodiment of a channel measurement characteristics block used in accordance with an aspect of the present invention;

FIG. 9b depicts one example of information included in the CMG-dependent channel measurement characteristics field of the block of FIG. 9a, in accordance with an aspect of the present invention;

FIG. 10 depicts one example of the command request block for a Set Extended Channel Measurements command used in accordance with an aspect of the present invention;

FIG. 11 depicts one embodiment of the logic associated with a channel processor collecting measurement data for one or more channel components, in accordance with an aspect of the present invention; and

FIG. 12 depicts one embodiment of the logic associated with an I/O processor storing measurement data for one or more channel components in channel utilization blocks, in accordance with an aspect of the present invention.

Best Mode for Carrying Out the Invention

In accordance with an aspect of the present invention, channel utilization is measured. In particular, various individual components of a channel are monitored and
5 measured to determine the utilization of each particular component. Further, in accordance with another aspect of the present invention, when the system is in logical partition mode, the collected measurement data reflects the utilization of the channel (or channel component) by a
10 particular logical partition, as well as the utilization by other logical partitions in the system, which are coupled to the channel (or channel component).

One embodiment of a computing environment incorporating and using the channel measurement capabilities of the
15 present invention is described with reference to FIG. 1. A computing environment 100 is based, for instance, on the Enterprise Systems Architecture (ESA)/390 offered by International Business Machines Corporation, Armonk, New York. ESA/390 is described in an IBM publication entitled
20 "Enterprise Systems Architecture/390 Principles of Operation," IBM Publication No. SA22-7201-06, July 1999, which is hereby incorporated herein by reference in its entirety. One example of a computing environment based on ESA/390 is the 9672 Parallel Enterprise Server offered by
25 International Business Machines Corporation.

Computing environment 100 includes, for example, at least one central processing complex (CPC) 102 having one or more logical partitions (LPARs) 104, a hardware systems area (HSA) 106 and at least one channel subsystem 108.

The resources of the CPC are allocated to the logical partitions. In particular, each logical partition 104 has one or more logical processors (not separately shown for clarity), each of which represents all or a share of a physical processor allocated to the partition. The logical processors of a particular partition may be either dedicated to the partition (so that the underlying processor resource is reserved for that partition) or shared with another partition (so that the underlying processor resources are potentially available to another partition).

In the particular example shown, each of logical partitions 1-M functions as a separate system having a resident operating system 109 (which may differ for each logical partition). In one embodiment, the operating system is the OS/390 or MVS/ESA operating system offered by International Business Machines Corporation.

Further, each partition has a portion of the CPC's main storage resources assigned to it and included within the storage are channel utilization blocks 110. One example of a channel utilization block 110 is described with reference to FIGs. 2a-2b.

Referring to FIG. 2a, channel utilization block 110 includes one or more channel utilization entries 200, each of which contains the utilization information for one channel. In one example, channel utilization entry 200 includes the following fields:

- (A) A channel-utilization-information validity (CUIV) map 202 that applies to the contents of the channel utilization entry. The bits

of the CUIV map indicate which words of the channel utilization entry contain valid channel utilization information;

5 (B) A timestamp 204 that identifies when channel utilization information was last stored in the channel utilization entry; and

10 (C) CMG-dependent channel-utilization information 206, the contents of which are dependent upon the channel measurement group (CMG) to which the channel belongs. The program can
15 determine the CMG for a channel by executing a Store Channel Measurement Characteristics command (described below) and examining the CMG field in the channel measurement characteristics block (CMCB) (also described below) for the associated channel.

Various examples of values for CMG and the corresponding contents of fields of entry 200 include the following:

20 CMG=0: A value of 0 in the CMG field indicates that the channel-measurement group for the specified channel path identifier (CHPID) is unknown. The CUIV bits are zeros and the contents of the remainder of the channel-utilization entry have no meaning.

25 CMG=1: The CMG-dependent channel-utilization information for CMG=1 includes the following, in one example:

(A) Channel-Path-Busy Time (CPBT) (CPC): This field contains the accumulation of all measured channel-path-busy intervals for the associated channel path. The channel path is busy when it is actively communicating with an attached control unit or device.

When the CPC is operating in LPAR mode, the CPBT (CPC) value includes the channel-path-busy intervals associated with all of the logical partitions that have access to the associated channel path.

(B) Channel-Path-Busy Time: When the CPC is operating in LPAR mode, the channel path busy time contains the accumulation of measured channel-path-busy intervals for the associated channel path. The accumulation only includes intervals that are associated with the logical partition that has access to this channel utilization block. The channel path is busy when it is actively communicating with an attached control unit or device.

When the CPC is operating in basic mode (non-LPAR), the contents of this field have no meaning and the appropriate bit of the CUIV field is zero.

CMG-2: The CMG-dependent channel-utilization information for CMG=2 includes the following, in one example:

the appropriate bit of the CUIV field is zero.

- 5 (D) Count of Data Units Written (CPC): This field contains an accumulated count of the number of data units that have been written using the associated channel path.

The channel measurement characteristics block for the associated channel path specifies the number of bytes contained in a data unit.

- 10 When the CPC is operating in LPAR mode, the count includes the data units that were written for all logical partitions that have access to the associated channel path.

- 15 (E) Count of Data Units Written: When the CPC is operating in LPAR mode, this field contains an accumulated count of the number of data units that have been written using the associated channel path. The count includes only the data units that were written for the
- 20 logical partition that has access to this channel-utilization block.

- 25 When the CPC is operating in basic mode, the contents of this field have no meaning and the appropriate bit of the CUIV field is zero.

- (F) Count of Data Units Read (CPC): This field contains an accumulated count of the number

of data units that have been read using the associated channel path. The channel measurement characteristics block for the associated channel path specifies the number of bytes contained in a data unit.

When the CPC is operating in LPAR mode, the count includes the data units that were read for all logical partitions that have access to the associated channel path.

(G) Count of Data Units Read: When the CPC is operating in LPAR mode, this field contains an accumulated count of the number of data units that have been read using the associated channel path. The count includes only the data units that were read for the logical partition that has access to this channel-utilization block.

When the CPC is operating in basic mode, the contents of this field have no meaning and the appropriate bit of the CUIV field is zero.

Returning to FIG. 1, coupled to the logical partitions is a hardware systems area (HSA) 106 which, in this embodiment, includes a channel subsystem extended CPMF data area 112. The channel subsystem extended CPMF data area includes measurement information for individual channels, as described with reference to FIG. 3. In particular, for each channel, the data area includes, for instance, channel measurement characteristics 300, total measurement data 302,

and measurement data 304 for each particular operating system associated with the specified channel. Further details regarding these fields are provided below.

Channel measurement characteristics 300 of a channel include, for example, maximum bus cycles specifying the maximum internal bus cycles per second, available for I/O operations on the specified channel path; maximum channel work units specifying the maximum number of channel work units that can be performed per second by the specified channel paths; maximum write data units specifying the maximum number of data units that can be written per second using the specified channel path; maximum read data units specifying the maximum number of data units that can be read per second using the specified channel path; and data unit size specifying the number of bytes of data that are contained in the data unit for the specified channel path.

Total measurement data 302 includes the total measurements for specified characteristics of a channel. In one example, the total measurement data includes the total bus cycles, the total work units, the total written data units and the total read data units, as explained further below.

Additionally, the channel measurement data per operating system includes the measurements of the specified characteristics on a per operating system basis.

Referring again to FIG. 1, also coupled to the HSA is channel subsystem 108, which is used in communicating with input/output (I/O) devices. Channel subsystem 108 directs the flow of information between the input/output devices and

main storage. It relieves the central processing units of the task of communicating directly with the input/output devices and permits data processing to proceed concurrently with input/output processing.

5 In one embodiment, channel subsystem 108 includes one or more I/O processors 114 coupled to one or more channels 116. Further, coupled to each channel is a physical channel link 118 that is used to communicate with the I/O devices. In particular, in one example, the link couples the channel
10 to a control unit, which is further coupled to one or more I/O devices.

Further details regarding a channel are described with reference to FIG. 4. In one embodiment, each channel 116 includes, for instance, a channel processor storage 400
15 coupled to a host-bus bridge and DMA controller 402 for providing access, via a system bus 404, to the operating system and other components of the CPC. Additionally, coupled to the host-bus bridge and DMA controller is an internal bus 406, which is coupled to a channel processor
20 408 and an adapter card 410. The adapter card provides access to the I/O devices via an external link 412.

One example of a channel is a FICON channel offered by International Business Machines Corporation. One example of a FICON channel is described in "IBM S/390 FICON
25 Implementation Guide", IBM Publication No. SG24-5169-00 (Nov. 1999), which is hereby incorporated herein by reference in its entirety.

In one embodiment, channel processor storage 400 includes a channel processor universal CPMF data area 414

used in storing various measurement information for the channel. As shown in FIG. 5, channel processor universal CPMF data area 412 includes, for instance, channel measurement characteristics 500, total channel measurement data 502, and measurement data 504 for each operating system coupled to the channel.

Channel measurement characteristics data 500 includes, for instance, maximum units 506 for a channel component. For example, maximum units 506 includes the maximum bus cycles (e.g., for Component 1 -- the internal bus) of the channel, the maximum channel work units (e.g., for Component 2 -- the channel processor), the maximum write data units (e.g., for Component 3 -- the external link), and the maximum read data units (e.g., for Component 4 -- the external link) for the channel.

Total channel measurement data 502 includes the total measurements for the components (e.g., the total bus cycles, total work units, total written data units and the total read data units).

Similarly, the operating system measurement data includes an operating system timestamp 514, as well as accumulated units 516 for each operating system of a component. Again, this is the accumulated information for each component.

Described in detail above is one example of a computing environment incorporating and using aspects of the present invention. The above-described environment is only one example, however. Other computing environments can be used without departing from the spirit of the invention.

Further, for one or more aspects of the present invention, the computing environment need not be in logical partitioning (LPAR) mode. Basic mode (non-LPAR) can also benefit from aspects of the present invention.

5 Channel subsystems are further described in Casper et al., U.S. Patent No. 5,526,484, entitled "Method and System for Pipelining the Processing of Channel Command Words," issued on June 11, 1996, as well as in Galbraith et al., U.S. Patent No. 5,265,250, entitled "Channel Measurement
10 Method and Means," issued on November 23, 1993, each of which is hereby incorporated herein by reference in its entirety.

In accordance with an aspect of the present invention, various components of the channel are individually
15 measurable. These components include, for instance, internal bus 406, channel processor 408, and external link 412. By measuring these components individually, specific information about the individual components, as well as about the channel as a whole, can be gathered and employed
20 in work management decisions, billing situations, system performance, as well as other areas.

Each of the various components is measured using a channel path measurement facility (CPMF). The channel path measurement facility may be initiated under various
25 conditions, as described with reference to FIG. 6. As one example, the operating system may run the channel path measurement facility when an initial program load (IPL) is performed, STEP 600. As a further example, the operating system runs the channel path measurement facility when an
30 operator selects an SRM parmlib member using an OS/390 Set

command, STEP 602. As a further example, the operating system may run the channel path measurement facility when an operator configures a channel path (CHPID) online, STEP 604.

Regardless of the triggering event for initiating the channel path measurement facility, a determination is made as to whether the parmlib specifies a channel path measurement facility (CPMF) keyword, INQUIRY 606. In particular, a decision is made as to whether the systems programmer chose to run with a parmlib member that specifically indicated the desired CPMF mode (e.g., compatibility mode, CPMF=COMPAT, in which the individual components are not measured; or extended mode, CPMF=EXTENDED, in which the individual components are measured in accordance with aspects of the present invention).

If the CPMF keyword was specified, then the system operates in the mode selected, STEP 608. However, if the systems programmer did not specifically set the CPMF parameter, then the operating system chooses the CPMF mode based on the set of channel path ids found in the machine. In particular, a determination is made as to whether an extended measurement mode CHPID is found, INQUIRY 610. If any of the online CHPIDs desire extended mode for gathering the performance data, then CPMF is initialized in extended mode, STEP 612. Otherwise, if no CHPIDs desiring extended mode are found, the system runs in the old compatibility mode, STEP 614. This completes initialization of the channel path measurement facility in the desired mode, STEP 616.

In one embodiment, both the compatibility mode and the extended mode can be active at the same time. That is, one facility can be activated in one mode, and another facility can be activated in another mode. This is true for both the
5 same logical partition and across multiple logical partitions.

Assuming that the channel path measurement facility is set to extended mode, the channel path measurement facility collects data on the various components of the channel, in
10 accordance with an aspect of the present invention. An overview of one embodiment of the logic employed to collect the various data is described with reference to FIG. 7.

Initially, a Store Channel Measurement Characteristics CHSC command is used by the operating systems to learn about
15 the measurement characteristics (or attributes) of each channel that is to be measured, STEP 700. That is, the operating systems learn about the characteristics of the various components of the channel to be measured. In one example, the measurement characteristics include the maximum
20 bus cycles, which is an attribute of internal bus 406 (FIG. 4); maximum channel work units, which are attributes of channel processor 408; and maximum written/read data units, which are attributes associated with external link 412. Further, the characteristics include the data unit size.

25 In addition to using the Store Channel Measurement Characteristics CHSC command to learn about the measurement attributes, a Set Extended Channel Measurements CHSC command (described below) is used by the operating system to start the channel path measurement facility and to provide to the

I/O processor a program data area for the channel utilization blocks, STEP 702.

Thereafter, each channel processor collects measurement data, via, for instance, the channel path measurement facility, for the various channel components contained in that channel and places the data in channel processor universal CPMF data area 414 (FIG. 4) contained in channel processor storage 400. Then, at each proper interval, the data is copied from data area 414 to channel subsystem extended CPMF data area 112 (FIG. 1) for that channel, STEP 704.

Additionally, the I/O processor collects from each of the channel subsystem extended CPMF data areas the data for all of the channels, reformats it and stores it in the channel utilization blocks in the previously provided program data area, STEP 706. The operating system then observes the information that has been placed in the channel utilization blocks and is able to interpret the information using the measurement characteristics that apply to each channel that were previously gathered (in STEP 700), STEP 708. This interpreted information provides the utilization of the measured channel components.

Further details regarding the processing performed by the various units of the central processing complex to measure the utilization of the individual components of a channel are described with reference to FIGs. 8-12. In particular, FIG. 8 describes one embodiment of the processing performed by one or more of the operating systems; FIG. 11 depicts one embodiment of the logic performed by one or more of the channel processors; and FIG.

12 depicts one embodiment of the logic performed by one or more of the I/O processors.

Referring to FIG. 8, initially, the operating system collects the channel measurement characteristics data for each channel associated with that operating system, using the Store Channel Measurement Characteristics CHSC command, STEP 800. As one example, the command request block for the store command includes an op code specifying the Store Channel Measurement Characteristics command, as well as an identifier for each channel path (CHPID) for which information is requested.

In response to this request, a command response block for the Store Channel Measurement Characteristics command is provided. This response block includes, for instance, one or more channel measurement characteristics blocks. In particular, a channel measurement characteristics block may be stored for one or more of the specified CHPIDs, beginning with the CHPID specified by the first CHPID field. One example of a channel measurement characteristics block is described with reference to FIG. 9a.

In one example, a channel measurement characteristics block 900 includes, for instance, one or more flags 902, a channel path identifier (CHPID) 904, a channel measurement characteristics validity (CMCV) indicator 906, a channel measurement group (CMG) 908 and a channel measurement group-dependent measurement characteristics field 910, each of which is described below.

Flags 902 provide indicators that enable the proper interpretation of the information in the channel measurement

facility is provided, when the CPC is operating in basic mode. However, when the CPC is operating in LPAR mode, one channel path measurement facility is provided for each logical partition. The phrase "the channel path measurement
5 facility" used herein implies the CPC channel path measurement facility, when the CPC is operating in basic mode, or the channel path measurement facility associated with the logical partition executing the command, when the CPC is operating in LPAR mode. One example of the request
10 block used for the Set Extended Channel Measurement command is described with reference to FIG. 10.

In one example, a command request block 1000 for the Set Extended Channel Measurement command includes an operation code 1002 specifying the operation to be
15 performed. In one example, this code may indicate a start of the channel path measurement facility for the Set Extended Channel Measurements command; a stop of the channel path measurement facility for the Set Extended Channel Measurements command; or a test of the status of the channel
20 path measurement facility for the Set Extended Channel Measurements command.

Additionally, the command request block includes a key 1004 used by the channel path measurement facility to access the channel utilization block. Further, it includes
25 utilization block addresses 1006. When the operation code specifies a start operation, the channel utilization block addresses contain the absolute addresses of, for instance, two 4k-byte areas in main storage which collectively make up the channel utilization block. Each part (i.e., 4k area) of
30 the channel utilization block contains utilization information for a unique set of a predefined number (e.g.,

128) of channel paths. When the operation code specifies a stop or a test operation, the contents of the channel utilization block address is ignored.

In response to executing the Set Extended Channel Measurement command, a response block is provided. This response block, indicates, for instance, the results of executing the Set Extended Channel Measurement command.

The channel path measurement facility provides the program (e.g., operating system) with the ability to accumulate channel path utilization information, and to accumulate the portion of shared channel path utilization attributable to a logical partition, when the CPC is operating in LPAR mode.

Returning to FIG. 8, subsequent to starting the channel path measurement facility, the channel subsystem begins to accumulate channel measurement data into the associated channel utilization block at predefined intervals (e.g., at least once every four seconds), STEP 804. One example of how this is performed is described below with reference to FIGs. 11 and 12.

Thereafter, the operating system determines the utilization of a particular channel component (such as, for instance, the channel processor, the internal bus or the external link), which is referred to herein as Component X, STEP 806.

One embodiment of how the operating system performs this determination is described with reference to STEP 808. For example, a copy of the channel utilization block, called

Sample # 1, is saved. Then, after a predefined delay (e.g., 15 seconds), another copy of the channel utilization block, called Sample # 2, is also saved. Subsequently, the "change in channel Component X units" between the sample periods is
5 calculated by subtracting the count of channel Component X units from Sample # 1 from the count of channel Component X units from Sample # 2. (For example, the count of bus cycles for the internal bus of Sample # 1 is subtracted from the count of bus cycles for the internal bus of Sample # 2.
10 Similar computations are made for the various characteristics of the other components.)

Additionally, the "change in channel time" between the sample periods is calculated by subtracting the channel timestamp for Sample # 1 from the channel timestamp for
15 Sample # 2. Thereafter, the "average change in channel Component X units per second" during this sample period is calculated by dividing the change in channel Component X units by the change in channel time. The utilization of channel Component X, during the sample period, is then
20 calculated by dividing the "average change in channel Component X units per second" by the maximum channel component units per second from the channel measurement characteristics.

Subsequent to determining the utilization of a channel
25 Component X, processing proceeds to STEP 804 in order to continue to collect and analyze data for another of the various channel components.

As mentioned above, in addition to the operating system performing tasks relevant to determining the utilization of

channel components, the channel processor also performs various tasks needed to collect measurement data relating to a measurable channel component. One embodiment of the logic associated with collecting this data is described with
5 reference to FIG. 11.

Initially, the channel processor is reset and initialized, STEP 1100. Thereafter, the channel processor stores its channel measurement characteristics (CMC) into the channel subsystem extended CPMF data area in the HSA,
10 STEP 1102. Subsequently, a determination is made as to whether channel work is pending, INQUIRY 1104. In one example, this determination is made by checking an internal status indicator. If no work is pending, then no data need be collected, thus processing continues with INQUIRY 1106.

At INQUIRY 1106, a determination is made as to whether a predefined time period (e.g., at least two seconds) has passed since the HSA channel measurement data has been updated. If the predefined amount of time has not elapsed, then processing continues with INQUIRY 1104. However, if
20 the predefined time interval has passed, then the channel's copy of the measurement data is stored into the HSA, STEP 1108. In particular, the data stored in the channel processor universal CPMF data area is copied to the channel subsystem extended CPMF data area. Thereafter, processing
25 continues with INQUIRY 1104.

At INQUIRY 1104, if channel work is pending, then the requested I/O operation is performed for the specified operating system, STEP 1110. Additionally, measurement data related to the current I/O operation is collected for each
30 measurable channel component, STEP 1112. The new measurement

data is then added to the accumulated measurement data for the particular operating system and to the accumulated total channel measurement data in the channel processor universal CPMF data, STEP 1114. Additionally, the measurement data
5 timestamp is updated. Thereafter, processing continues with INQUIRY 1106.

Processing related to the I/O processor's collection of data is described with reference to FIG. 12. Initially, a set loop count is set equal to a variable M, where M is
10 equal to the number of operating systems, STEP 1200. Thereafter, a determination is made as to whether the extended channel path monitoring facility is active for this operating system, INQUIRY 1202.

If the facility is not active for this operating
15 system, then the loop count is decremented by a predefined amount (e.g., by one), and a determination is made as to whether the last operating system has been processed, INQUIRY 1204. If the last operating system has been processed, then the logic polls for other IOP work to
20 perform, STEP 1206. Otherwise, processing continues with INQUIRY 1202 for the next operating system.

At INQUIRY 1202, if the extended monitoring facility is active for this operating system, then a channel count is set equal to a variable, N, which reflects the number of
25 channels, STEP 1208. Thereafter, the total measurements data and the operating system measurement data for the channels in which the operating system has access are fetched from the channel subsystem extended CPMF data area of the HSA and stored into the operating system's channel
30 utilization blocks, STEP 1210. Subsequently, the variable,

channel count, is decremented by a predefined amount (e.g., one), and a determination is made as to whether the last channel has been processed, INQUIRY 1212. If the last channel has been processed, then processing continues with INQUIRY 1204. Otherwise, processing continues with STEP 1210.

Described in detail above is a measurement facility that measures utilization of individual channel components. This advantageously provides utilization information in enough detail (e.g., work units, data units written, data units read and bus cycles used) to effectively assess the workload of a channel. Advantageously, measurements are provided that are tailored to the type of channel path, and which are meaningful in determining how, and to what degree, the channel is being utilized. The utilization measurements of the present invention include information concerning both the CPC level and the single logical partition level. In addition, in one aspect of the present invention, an operating system that is executing in a logical partition under LPAR is able to observe channel path utilization for all logical partitions, as well as for its own logical partition.

Although various components are described herein, this invention is not limited to those components. Aspects of this invention are universal and can be used with a wide range of components. Further, the characteristics described herein are only examples. Other characteristics can be used without departing from the spirit of the present invention.

The present invention can be included in an article of manufacture (e.g., one or more computer program products)

having, for instance, computer usable media. The media has embodied therein, for instance, computer readable program code means for providing and facilitating the capabilities of the present invention. The article of manufacture can be
5 included as a part of a computer system or sold separately.

Additionally, at least one program storage device readable by a machine, tangibly embodying at least one program of instructions executable by the machine to perform the capabilities of the present invention can be provided.

10 The flow diagrams depicted herein are just examples. There may be many variations to these diagrams or the steps (or operations) described therein without departing from the spirit of the invention. For instance, the steps may be performed in a differing order, or steps may be added,
15 deleted or modified. All of these variations are considered a part of the claimed invention.

Although preferred embodiments have been depicted and described in detail herein, it will be apparent to those skilled in the relevant art that various modifications,
20 additions, substitutions and the like can be made without departing from the spirit of the invention and these are therefore considered to be within the scope of the invention as defined in the following claims.

Claims

What is claimed is:

1 1. A method of determining utilization of channel
2 components of a computing environment, said method
3 comprising:

4 obtaining measurement data for a selected
5 component of a channel, said channel comprising a
6 plurality of components; and

7 using said measurement data to determine
8 utilization of said selected component.

1 2. The method of claim 1, wherein said obtaining
2 comprises obtaining measurement data for multiple components
3 of said plurality of components, and wherein said using
4 comprises using said measurement data to determine
5 utilization for each of said multiple components.

1 3. The method of claim 1, further comprising obtaining
2 one or more operational characteristics of said selected
3 component.

1 4. The method of claim 3, wherein said using further
2 comprises employing said one or more operational
3 characteristics to determine said utilization of said
4 selected component.

1 15. A method of obtaining information associated with
2 channel components of a computing environment, said method
3 comprising:

4 selecting a channel within said computing
5 environment to be monitored, said channel comprising a
6 plurality of components; and

7 obtaining data on one or more components of said
8 plurality of components.

1 16. The method of claim 15, wherein said obtaining
2 data comprises obtaining one or more operational
3 characteristics of said one or more components.

1 17. The method of claim 16, wherein at least one of
2 said one or more operational characteristics comprises a
3 maximal value of said operational characteristic.

1 18. The method of claim 15, wherein said obtaining
2 data comprises obtaining measurement data usable in
3 determining utilization of said one or more components.

1 19. The method of claim 15, wherein said obtaining
2 data comprises:

3 obtaining one or more operational characteristics
4 of said one or more components; and

5 obtaining measurement data for said one or more
6 components, wherein said one or more operational
7 characteristics and said measurement data are used to
8 determine utilization of said one or more components.

1 20. A method of determining utilization of channels of
2 a computing environment, said computing environment
3 comprising a plurality of logical partitions, and said
4 method comprising:

5 obtaining measurement data for a channel, said
6 measurement data being representative of use of said
7 channel by a logical partition involved in determining
8 the utilization and representative of use by one or
9 more other logical partitions of said plurality of
10 logical partitions; and

11 using said measurement data to determine
12 utilization of the channel.

1 21. A system of determining utilization of channel
2 components of a computing environment, said system
3 comprising:

4 means for obtaining measurement data for a
5 selected component of a channel, said channel
6 comprising a plurality of components; and

7 means for using said measurement data to determine
8 utilization of said selected component.

1 22. The system of claim 21, wherein said means for
2 obtaining comprises means for obtaining measurement data for
3 multiple components of said plurality of components, and
4 wherein said means for using comprises means for using said
5 measurement data to determine utilization for each of said
6 multiple components.

1 23. The system of claim 21, further comprising means
2 for obtaining one or more operational characteristics of
3 said selected component.

1 24. The system of claim 23, wherein said means for
2 using further comprises means for employing said one or more
3 operational characteristics to determine said utilization of
4 said selected component.

1 25. The system of claim 24, wherein said means for
2 obtaining measurement data comprises means for obtaining
3 said measurement data at a plurality of predefined
4 intervals, and wherein said means for using comprises:

5 means for determining an average change in the
6 measurement data over at least two intervals of said
7 plurality of predefined intervals; and

8 means for dividing said average change by a value
9 of at least one of said one or more operational
10 characteristics.

1 26. The system of claim 25, wherein said value is a
2 maximum value for that operational characteristic.

1 27. The system of claim 23, wherein said selected
2 component comprises an internal channel bus, and said one or
3 more operational characteristics of said internal bus
4 comprise a maximum number of bus cycles.

1 28. The system of claim 23, wherein said selected
2 component comprises a channel processor, and said one or
3 more operational characteristics of said channel processor
4 comprise a maximum number of channel work units.

1 29. The system of claim 23, wherein said selected
2 component comprises an external link of said channel, and
3 said one or more operational characteristics of said
4 external link comprise at least one of a maximum number of
5 written data units, a maximum number of read data units, and
6 a size of said data units.

1 33. A system of obtaining information associated with
2 channel components of a computing environment, said system
3 comprising:

4 means for selecting a channel within said
5 computing environment to be monitored, said channel
6 comprising a plurality of components; and

7 means for obtaining data on one or more components
8 of said plurality of components.

1 34. The system of claim 33, wherein said means for
2 obtaining data comprises means for obtaining one or more
3 operational characteristics of said one or more components.

1 35. The system of claim 34, wherein at least one of
2 said one or more operational characteristics comprises a
3 maximal value of said operational characteristic.

1 36. The system of claim 33, wherein said means for
2 obtaining data comprises means for obtaining measurement
3 data usable in determining utilization of said one or more
4 components.

1 37. The system of claim 33, wherein said means for
2 obtaining data comprises:

3 means for obtaining one or more operational
4 characteristics of said one or more components; and

5 means for obtaining measurement data for said one
6 or more components, wherein said one or more
7 operational characteristics and said measurement data
8 are used to determine utilization of said one or more
9 components.

1990-1991		1991-1992		1992-1993		1993-1994		1994-1995		1995-1996		1996-1997		1997-1998		1998-1999		1999-2000		2000-2001		2001-2002		2002-2003		2003-2004		2004-2005		2005-2006		2006-2007		2007-2008		2008-2009		2009-2010		2010-2011		2011-2012		2012-2013		2013-2014		2014-2015		2015-2016		2016-2017		2017-2018		2018-2019		2019-2020		2020-2021		2021-2022		2022-2023		2023-2024		2024-2025		2025-2026		2026-2027		2027-2028		2028-2029		2029-2030		2030-2031		2031-2032		2032-2033		2033-2034		2034-2035		2035-2036		2036-2037		2037-2038		2038-2039		2039-2040		2040-2041		2041-2042		2042-2043		2043-2044		2044-2045		2045-2046		2046-2047		2047-2048		2048-2049		2049-2050		2050-2051		2051-2052		2052-2053		2053-2054		2054-2055		2055-2056		2056-2057		2057-2058		2058-2059		2059-2060		2060-2061		2061-2062		2062-2063		2063-2064		2064-2065		2065-2066		2066-2067		2067-2068		2068-2069		2069-2070		2070-2071		2071-2072		2072-2073		2073-2074		2074-2075		2075-2076		2076-2077		2077-2078		2078-2079		2079-2080		2080-2081		2081-2082		2082-2083		2083-2084		2084-2085		2085-2086		2086-2087		2087-2088		2088-2089		2089-2090		2090-2091		2091-2092		2092-2093		2093-2094		2094-2095		2095-2096		2096-2097		2097-2098		2098-2099		2099-2100		2100-2101		2101-2102		2102-2103		2103-2104		2104-2105		2105-2106		2106-2107		2107-2108		2108-2109		2109-2110		2110-2111		2111-2112		2112-2113		2113-2114		2114-2115		2115-2116		2116-2117		2117-2118		2118-2119		2119-2120		2120-2121		2121-2122		2122-2123		2123-2124		2124-2125		2125-2126		2126-2127		2127-2128		2128-2129		2129-2130		2130-2131		2131-2132		2132-2133		2133-2134		2134-2135		2135-2136		2136-2137		2137-2138		2138-2139		2139-2140		2140-2141		2141-2142		2142-2143		2143-2144		2144-2145		2145-2146		2146-2147		2147-2148		2148-2149		2149-2150		2150-2151		2151-2152		2152-2153		2153-2154		2154-2155		2155-2156		2156-2157		2157-2158		2158-2159		2159-2160		2160-2161		2161-2162		2162-2163		2163-2164		2164-2165		2165-2166		2166-2167		2167-2168		2168-2169		2169-2170		2170-2171		2171-2172		2172-2173		2173-2174		2174-2175		2175-2176		2176-2177		2177-2178		2178-2179		2179-2180		2180-2181		2181-2182		2182-2183		2183-2184		2184-2185		2185-2186		2186-2187		2187-2188		2188-2189		2189-2190		2190-2191		2191-2192		2192-2193		2193-2194		2194-2195		2195-2196		2196-2197		2197-2198		2198-2199		2199-2200		2200-2201		2201-2202		2202-2203		2203-2204		2204-2205		2205-2206		2206-2207		2207-2208		2208-2209		2209-2210		2210-2211		2211-2212		2212-2213		2213-2214		2214-2215		2215-2216		2216-2217	
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1 38. A system of determining utilization of channels of
2 a computing environment, said computing environment
3 comprising a plurality of logical partitions, and said
4 system comprising:

5 means for obtaining measurement data for a
6 channel, said measurement data being representative of
7 use of said channel by a logical partition involved in
8 determining the utilization and representative of use
9 by one or more other logical partitions of said
10 plurality of logical partitions; and

11 means for using said measurement data to determine
12 utilization of the channel.

1 39. A system of determining utilization of channel
2 components of a computing environment, said system
3 comprising:

4 at least one processor adapted to obtain
5 measurement data for a selected component of a channel,
6 said channel comprising a plurality of components; and

7 at least one processor adapted to use said
8 measurement data to determine utilization of said
9 selected component.

1 42. At least one program storage device readable by a
2 machine, tangibly embodying at least one program of
3 instructions executable by the machine to perform a method
4 of determining utilization of channel components of a
5 computing environment, said method comprising:

6 obtaining measurement data for a selected
7 component of a channel, said channel comprising a
8 plurality of components; and

9 using said measurement data to determine
10 utilization of said selected component.

1 43. The at least one program storage device of claim
2 42, wherein said obtaining comprises obtaining measurement
3 data for multiple components of said plurality of
4 components, and wherein said using comprises using said
5 measurement data to determine utilization for each of said
6 multiple components.

1 44. The at least one program storage device of claim
2 42, wherein said method further comprises obtaining one or
3 more operational characteristics of said selected component.

1 45. The at least one program storage device of claim
2 44, wherein said using further comprises employing said one
3 or more operational characteristics to determine said
4 utilization of said selected component.

1 46. The at least one program storage device of claim
2 45, wherein said obtaining measurement data comprises
3 obtaining said measurement data at a plurality of predefined
4 intervals, and wherein said using comprises:

5 determining an average change in the measurement
6 data over at least two intervals of said plurality of
7 predefined intervals; and

8 dividing said average change by a value of at
9 least one of said one or more operational
10 characteristics.

1 47. The at least one program storage device of claim
2 42, wherein said selected component comprises one of an
3 internal bus of said channel, a channel processor and an
4 external link of said channel.

1 48. The at least one program storage device of claim
2 42, wherein the channel is associated with a logical
3 partition of said computing environment involved in the
4 determining utilization, and wherein the measurement data
5 comprises data representative of use of said selected
6 component by said logical partition.

1 49. The at least one program storage device of claim
2 48, wherein the measurement data is further representative
3 of use of said selected component by one or more other
4 logical partitions of said computing environment.

1 50. An article of manufacture, comprising:

2 at least one computer usable medium having
3 computer readable program code means embodied therein
4 for causing the obtaining of information associated
5 with channel components of a computing environment, the
6 computer readable program code means in the article of
7 manufacture comprising:

8 computer readable program code means for
9 causing a computer to select a channel within said
10 computing environment to be monitored, said
11 channel comprising a plurality of components; and

12 computer readable program code means for
13 causing a computer to obtain data on one or more
14 components of said plurality of components.

1 51. The article of manufacture of claim 50, wherein
2 said computer readable program code means for causing a
3 computer to obtain data comprises computer readable program
4 code means for causing a computer to obtain one or more
5 operational characteristics of said one or more components.

1 52. The article of manufacture of claim 50, wherein
2 said computer readable program code means for causing a
3 computer to obtain data comprises computer readable program
4 code means for causing a computer to obtain measurement data
5 usable in determining utilization of said one or more
6 components.

1 54. At least one program storage device readable by a
2 machine, tangibly embodying at least one program of
3 instructions executable by the machine to perform a method
4 of determining utilization of channels of a computing
5 environment, said computing environment comprising a
6 plurality of logical partitions, and said method comprising:

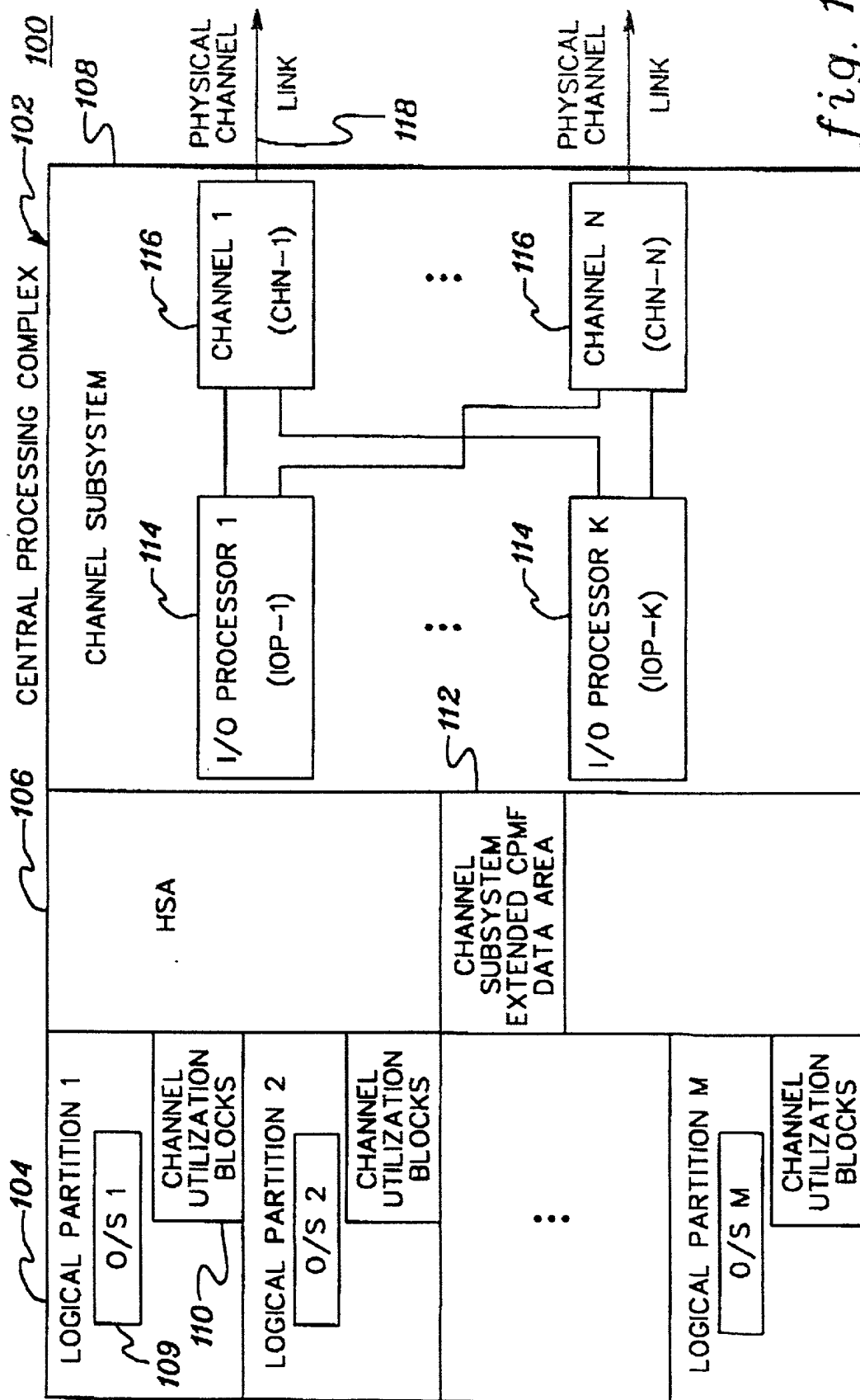
7 obtaining measurement data for a channel, said
8 measurement data being representative of use of said
9 channel by a logical partition involved in determining
10 the utilization and representative of use by one or
11 more other logical partitions of said plurality of
12 logical partitions; and

13 using said measurement data to determine
14 utilization of the channel.

* * * * *

[illegible]

The utilization of various individual components of a channel is determined in order to learn which portion of a
5 channel is busy and to what extent that portion is busy. The determination of a component's utilization is dependent on the type of component, as well as the operational characteristics of that component.



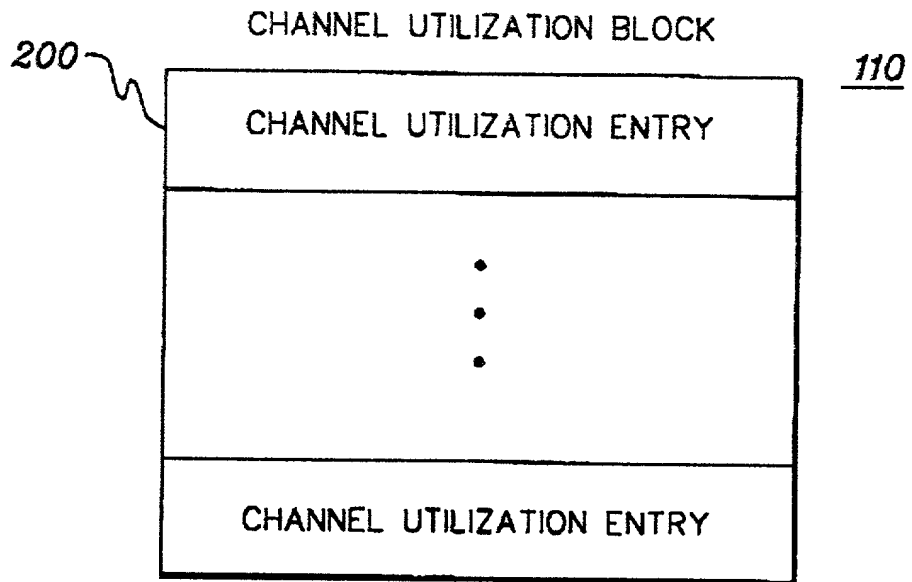


fig. 2A

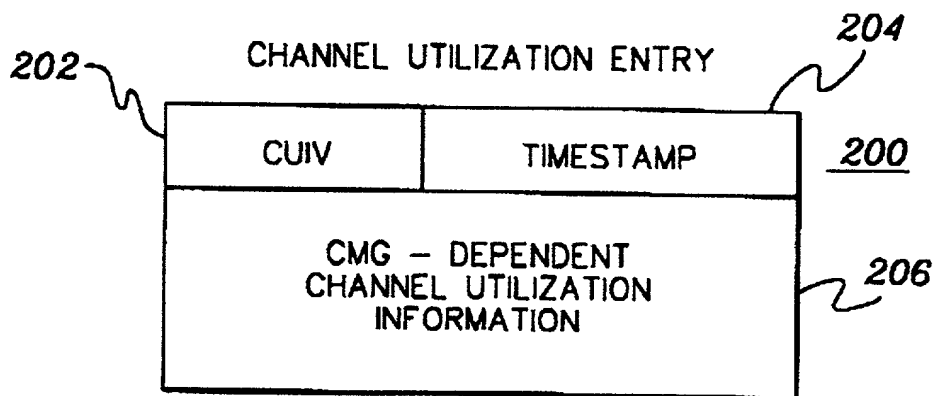


fig. 2B

112

CHANNEL SUBSYSTEM EXTENDED CPMF DATA

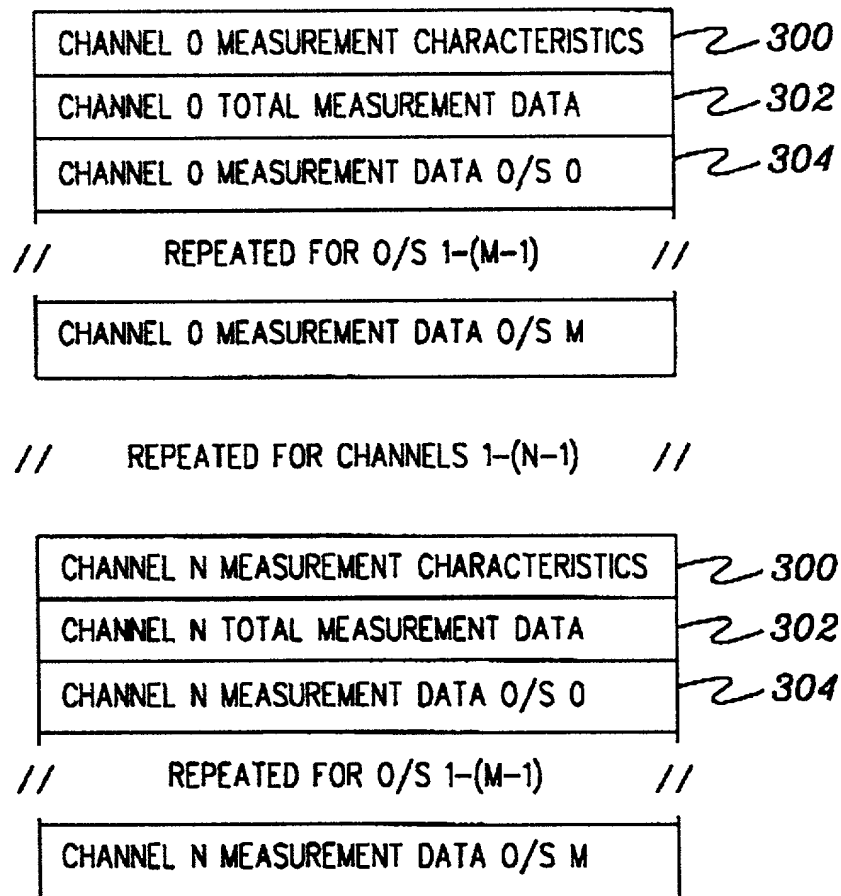


fig. 3

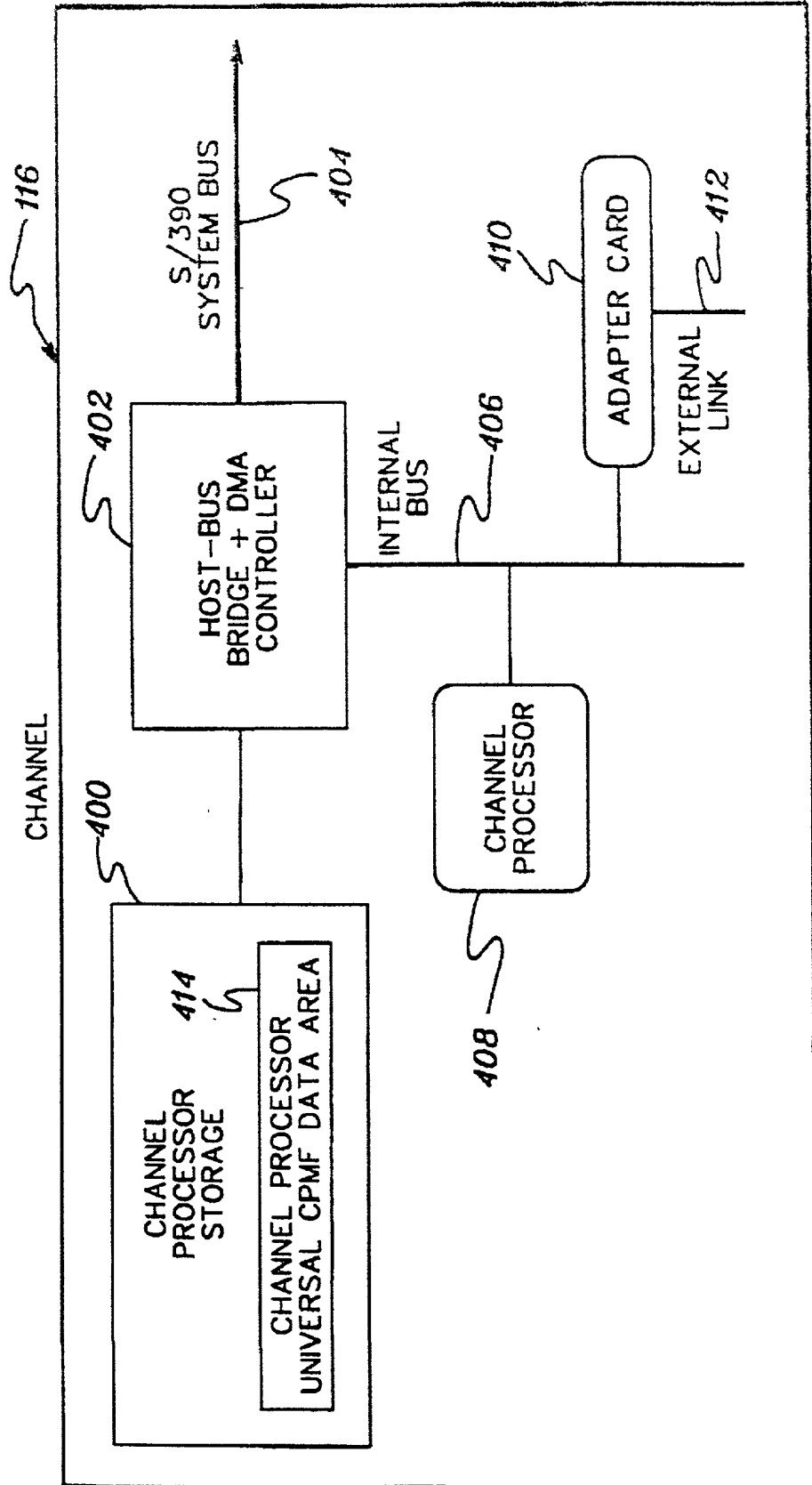


fig. 4

CHANNEL PROCESSOR UNIVERSAL CPMF DATA

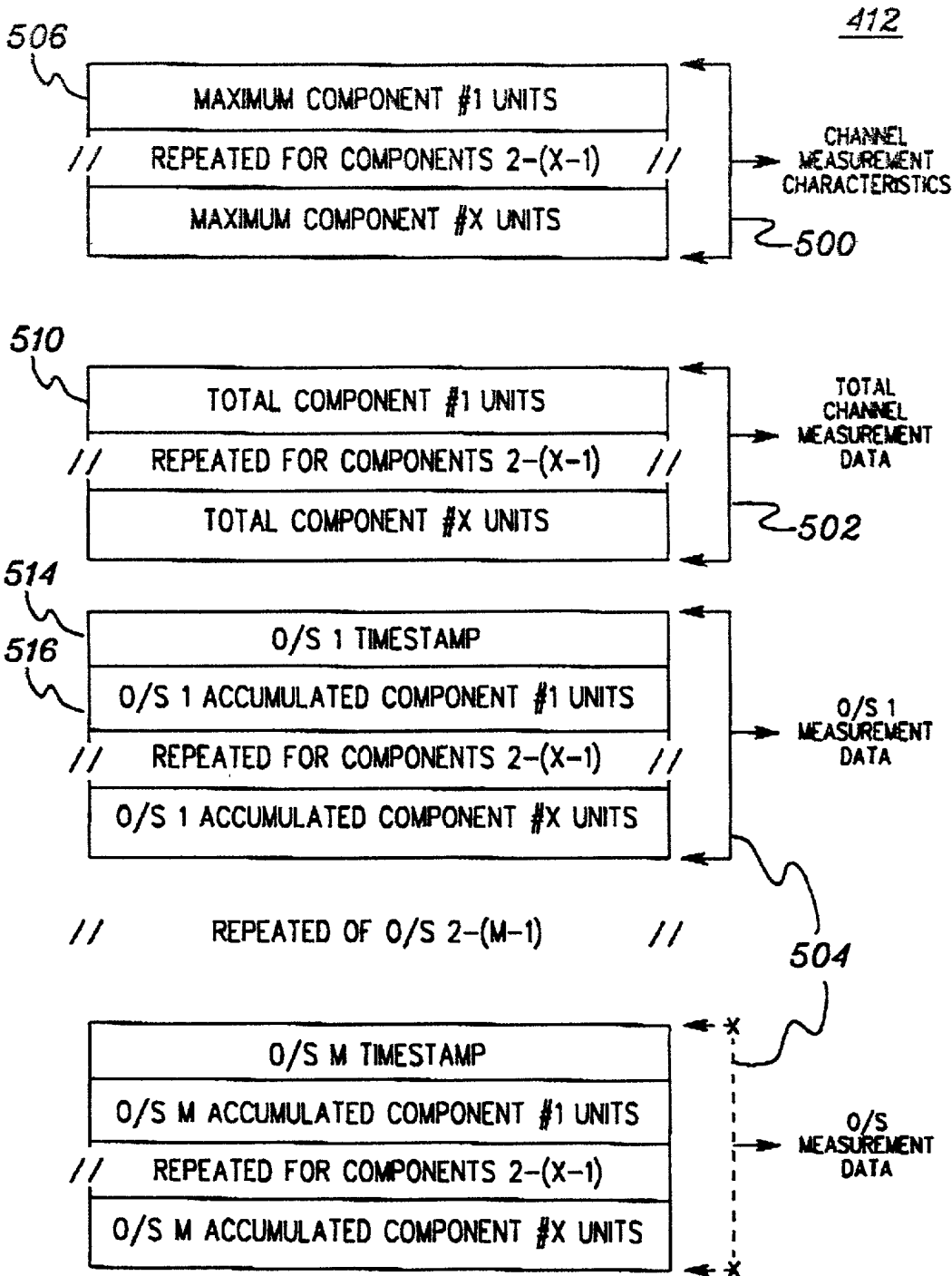
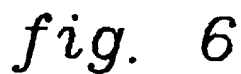


fig. 5



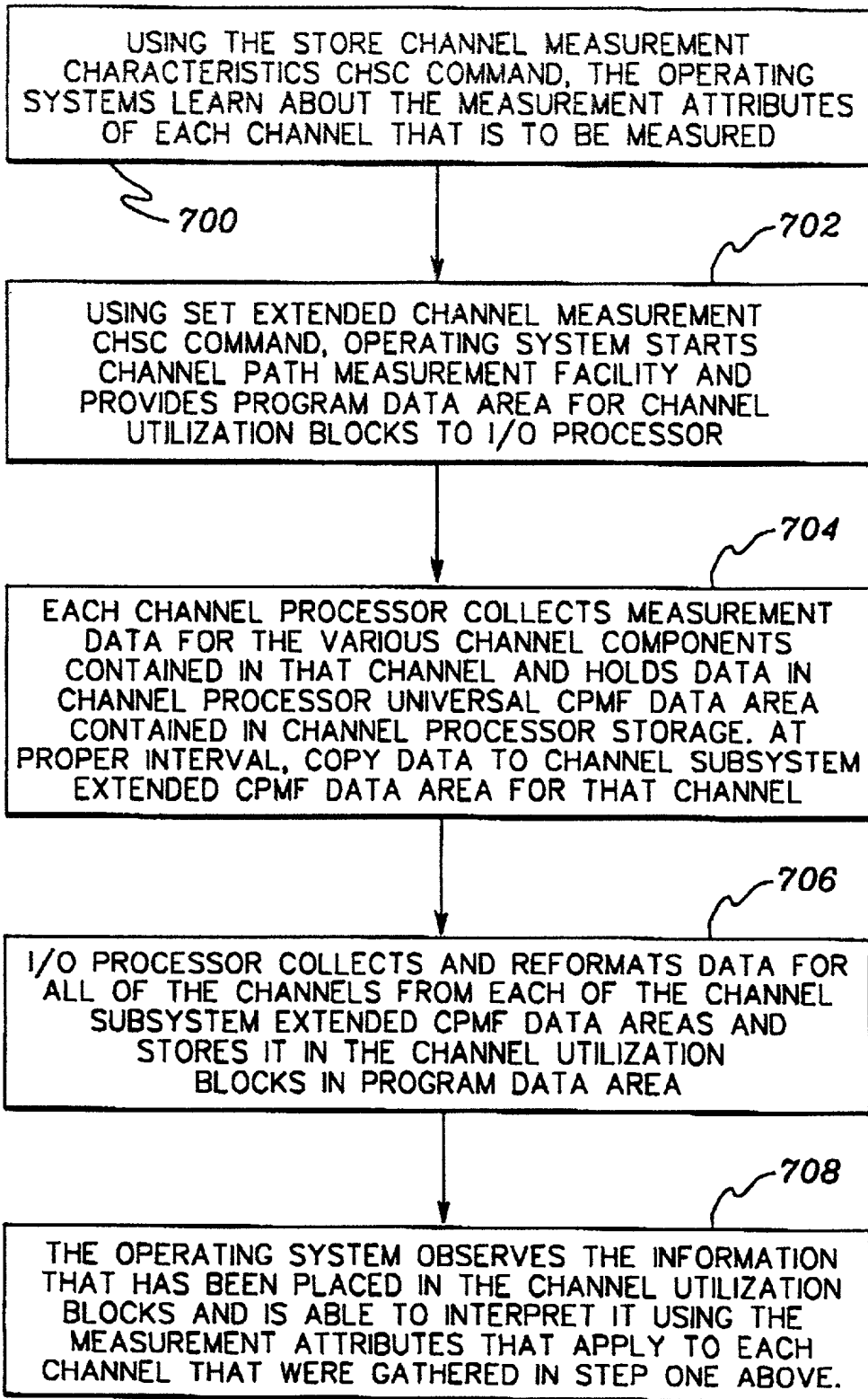
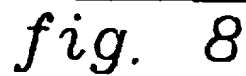


fig. 7



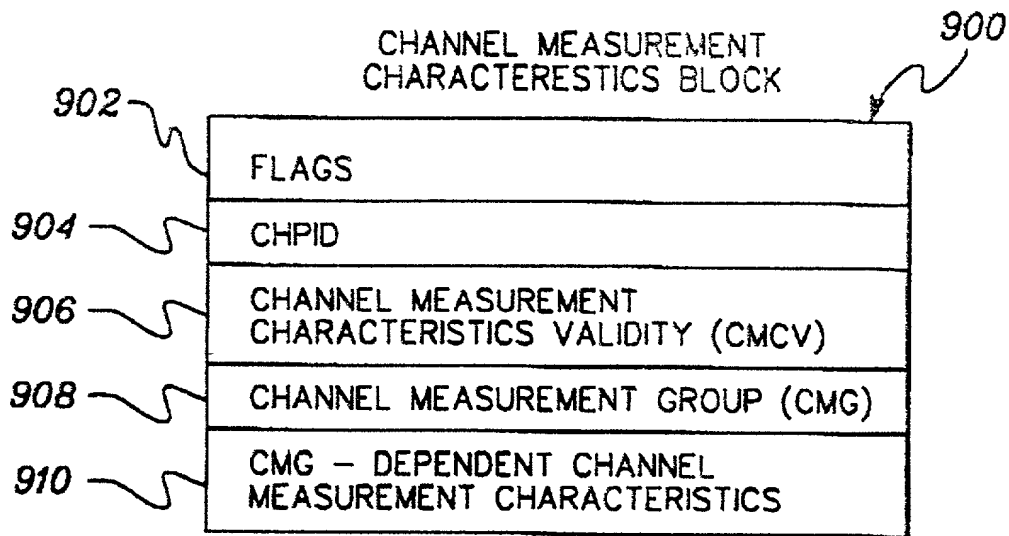


fig. 9A

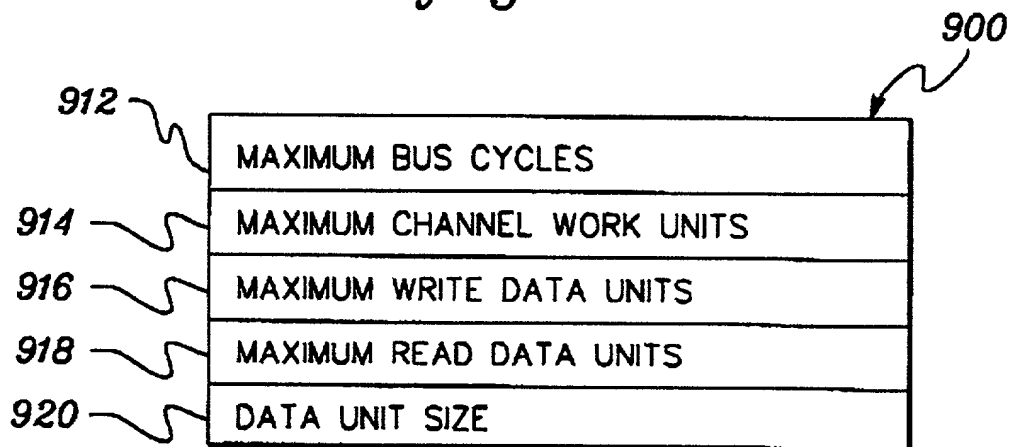


fig. 9B

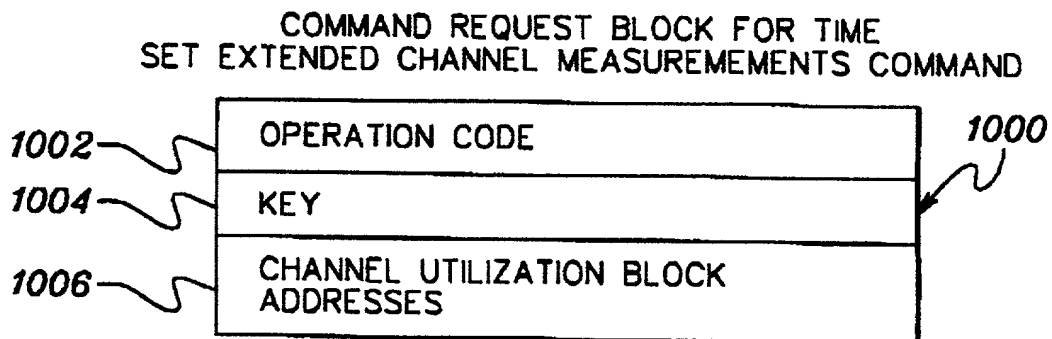


fig. 10

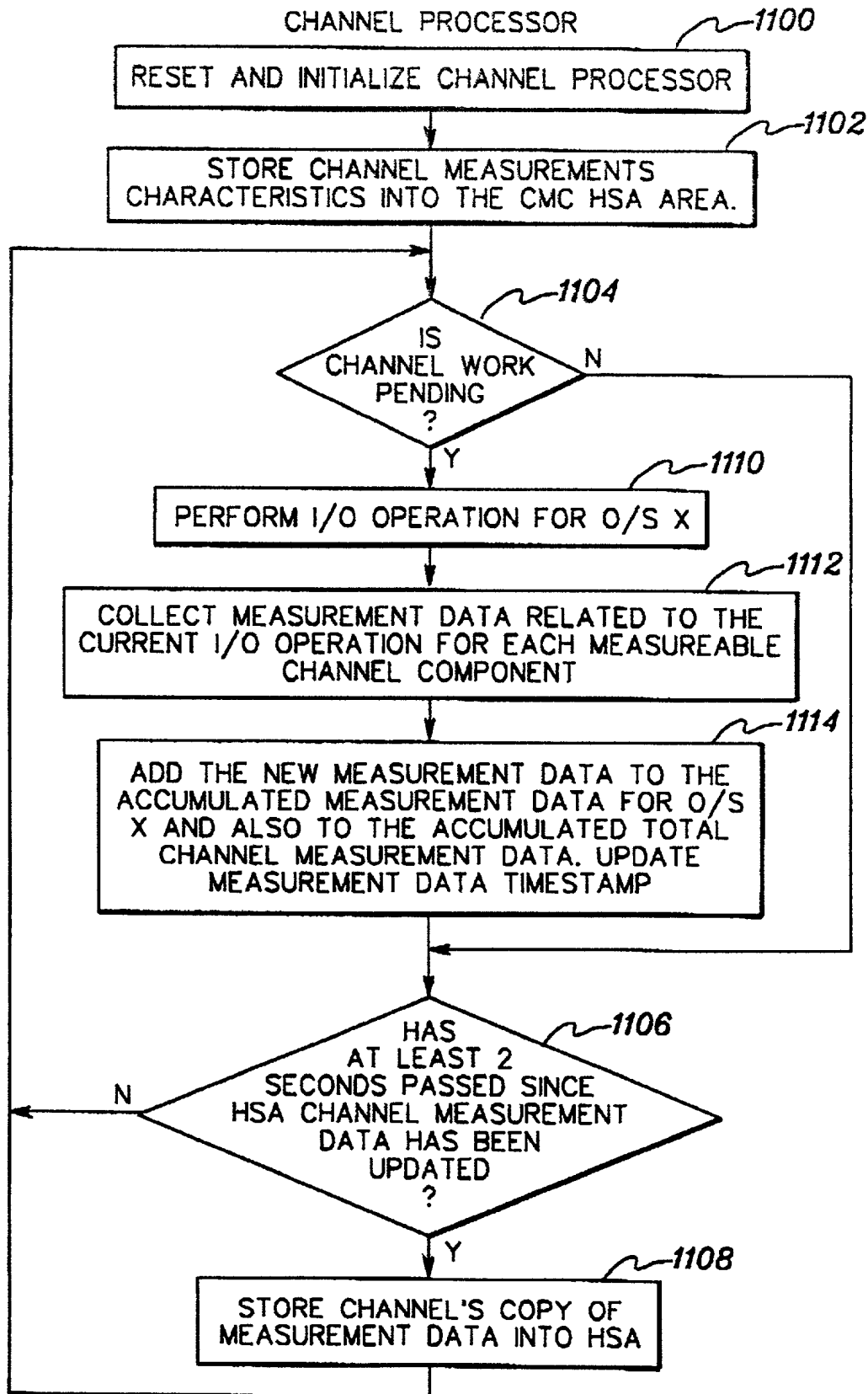
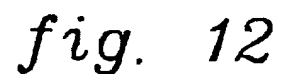


fig. 11



Docket No.
POU9-1999-0176-US1

Declaration and Power of Attorney For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

MEASURING UTILIZATION OF INDIVIDUAL COMPONENTS OF CHANNELS

the specification of which

(check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International Application Number _____ and was amended on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
_____	_____	_____	<input type="checkbox"/>
(Number)	(Country)	(Day/Month/Year Filed)	
_____	_____	_____	<input type="checkbox"/>
(Number)	(Country)	(Day/Month/Year Filed)	
_____	_____	_____	<input type="checkbox"/>
(Number)	(Country)	(Day/Month/Year Filed)	

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

(Application Serial No.)

(Filing Date)

(Application Serial No.)

(Filing Date)

(Application Serial No.)

(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)

(Filing Date)

(Status)
(patented, pending, abandoned)

(Application Serial No.)

(Filing Date)

(Status)
(patented, pending, abandoned)

(Application Serial No.)

(Filing Date)

(Status)
(patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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